## *Genomic Selection In Perennial Ryegrass*

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# IBERS

Sefydliad y Gwyddorau Biolegol, Amgylcheddol a Gwledig
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## Genomic selection in ryegrass

Leif Skøt

PAG XXI January 12-16 2013

bbsrc

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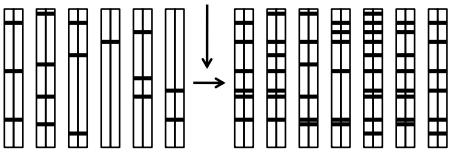
## Recurrent selection in forage crops

Selection and intermating to increase the frequency of desired alleles by repeated cycles



Selection index: $M_j = \Sigma b_i X_{ij}$

Gupta et al. 2010. Plant Breeding Reviews 33: 145-217

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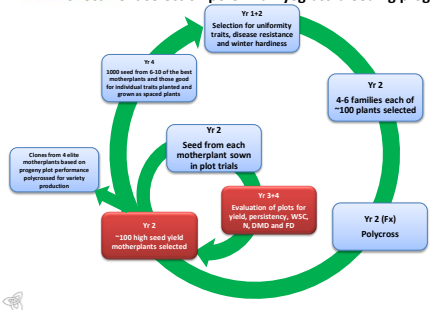
## IBERS recurrent selection perennial ryegrass breeding programme

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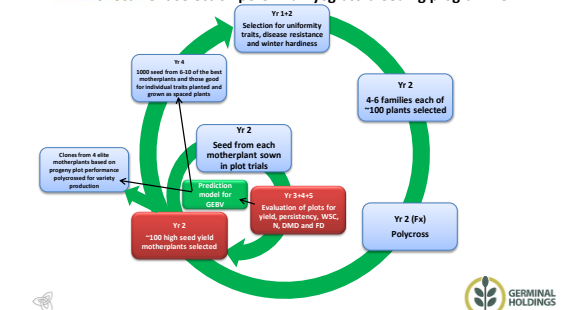
## IBERS recurrent selection perennial ryegrass breeding programme

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## Genomic selection

**Selection decisions based on genomically estimated breeding values derived from determining simultaneous effects of many molecular markers covering the entire genome**

Meuwissen et al. (2001) Genetics 157: 1819-1829

## Rationale

- Faster selection of candidates for production of synthetics
- Increase the number of recombinations per unit time
- Improve efficiency of introgression of beneficial trait from donor to breeding population?
- Reduce phenotyping costs?

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## Genomic selection
## Factors affecting accuracy

- **Proximity of marker to locus affecting trait**
  Increase marker density improves chances of marker close to QTL (LD = 0.13-0.53 up to 0.2 cM in *L. perenne* breeding population)
- **Size of training population with phenotypes and genotypes**
  Increased size likely to increase accuracy
- **Heritability of trait**
  Increase replication (costs money)
- **Number of QTL affecting the trait of interest**
  Cannot be changed

## Genotypes used within the Intermediate diploid population

| Parental plants | Generation of introduction |
|---|---|
| Italian* ecotype (3 plants) | F1 |
| Commercial genotype (2 plants) | F1 |
| RMV resistant genotype (2 plants) | F1 |
| High spring yield genotype (1 plant) | F10 |
| Later heading genotype (1 plant) | F11 |
| ***Total genotypes so far*** | ***9*** |

** Not Italian ryegrass, these are* **Lolium perenne** *ecotypes.*

Richard Hayes

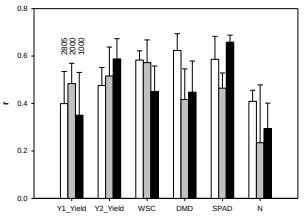
## Heritabilities for various traits

| Population | Yield Y1 | Yield Y2 | WSC | DMD | SPAD | Seed Yield | N |
|---|---|---|---|---|---|---|---|
| Intermediate | 0.38 | 0.35 | 0.72 | 0.66 | 0.41 | 0.12 | 0.40 |
| Late | 0.08 | 0.25 | 0.56 | 0.60 | 0.63 | 0.10 | 0.23 |

Alan Lovatt and Richard Hayes

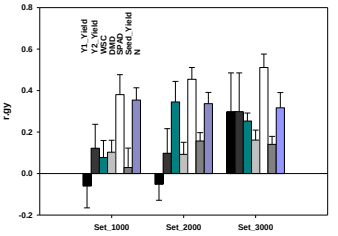
## Cross validation tests in *Lolium perenne* breeding populations with DArT markers

Cross validation in intermediate population at three marker densities




rrBLUP package: Endelman (2011) Plant Genome 4:250-255

## Cross validation in late flowering population (105)

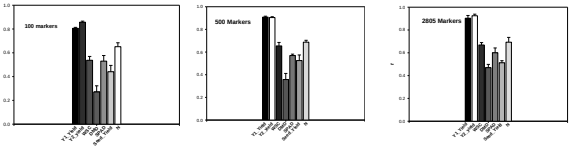



## Prediction accuracy with 2805 DArT markers

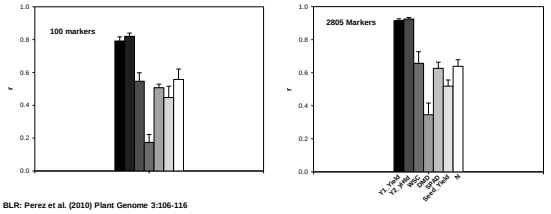
| Training to test population | Yield Y1 | Yield Y2 | WSC | DMD | SPAD | Seed Yield |
|---|---|---|---|---|---|---|
| Late to Intermediate | 0.47 | 0.34 | 0.22 | 0.32 | 0.01 | 0.80 |
| Intermediate to late | 0.19 | 0.17 | 0.22 | 0.10 | 0.00 | 0.00 |

rrBLUP package: Endelman (2011) Plant Genome 4:250-255

## Cross validation combined breeding population (157) Ridge regression



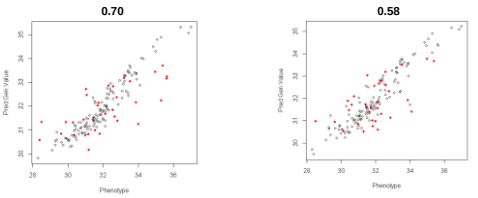
## Cross validation in both breeding populations
## Bayesian LASSO



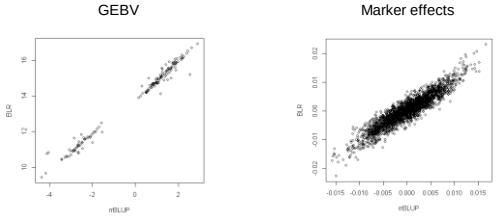

BLR: Perez et al. (2010) Plant Genome 3:106-116

## Cross validation in both breeding populations
## Bayesian LASSO

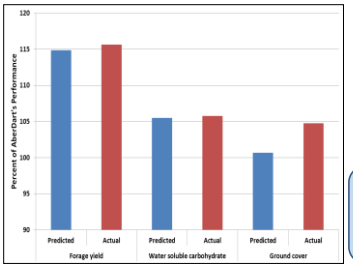
WSC




## Genetic values and marker effects
## Bayesian Lasso vs rrBLUP




## Ba14074
## Predicted (phenotype) vs. Performance




**Clones from 4 elite motherplants based on progeny plot performance polycrossed for variety production**

Richard Hayes

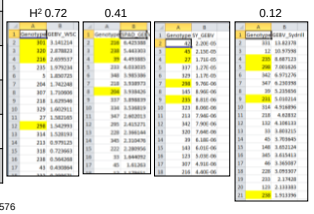
## Variety development in ryegrass and prediction of best crosses

**Predicted progeny value**

| Cross | $SPV_{10\%}$ | Mean GEBV | SD GEBV |
|---|---|---|---|
| Ba14150 (215, 298, 301 320) | 2.8355 | 2.5556 | 0.1555 |
| Random_WSC (39,218,307, 348) | 0.2463 | -0.0686 | 0.1749 |
| Ba14281 (High SPAD) (39,204,216,238 | 5.8445 | 5.0752 | 0.4274 |
| BA14246 (High seed yield) (25,45,235,298) | 1.51x10-5 | 1.43x10-5 | 8.48X10-7 |
| BA14151 (Seed drill) (231, 235, 238, 298) | 6.2298 | 5.6531 | 0.5767 |

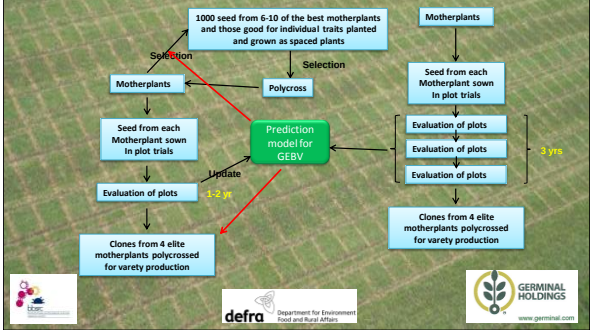
**Phenotypic selection vs GEBV**

$H^2$ 0.72 | 0.41 | 0.12



Zhong and Jannink (2007) Genetics 177: 567-576
Bernardo et al. (2006) Crop Sci 46: 1972-1980

## Possible scenario for incorporating GS in ryegrass breeding



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